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# An Investigation of the Comparative Loss of Weight of the Brine Cured, Pickle Cured, and Kench Cured Fish

By H. R. M. MONTALBAN

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## PURPOSE OF INVESTIGATION

Following the suggestion of Instructor C. L. Anderson early in the winter quarter, (University of Washington, Seattle) this experimental work has been done with the purpose of showing the comparative efficiency of the brine, pickle and kench method of removing moisture from the fish. This research was undertaken under his personal supervision, and was intended to cover different kinds of fish, but for the limited time available it is confined to split cod, gibbed and round herring. This paper, resulting from a six months' work in the laboratory, is by no means complete, but it is hoped that besides serving as a reference or guide, it may be a step on the way toward further investigation.

## LITERATURE

It is worth while to give a short review of the references consulted from time to time. Among the most important ones are the following:

Taylor — Principles Involved in the Preservation of Fish by Salt, U. S. Bureau of Fisheries Document No. 919.

Tressler—Some Considerations Concerning the Salting of Fish, U. S. Bureau of Fisheries Document No. 884.

Weber, Houghton and Wilson—The Maine Sardine Industry, U. S. Bureau of Chemistry Bulletin No. 908.

Finch—Some Observations on Mild Cured Salmon, Pacific Fisherman Magazine, May, 1924, Vol. XXII, No. 5.

The first paper is by Harden F. Taylor, at one time chief technologist for the Bureau of Fisheries, and is a contribution from the Fishery Products Laboratory at Washington, D. C. As the title indicates, it presents a discussion of the principles involved in the preservation of fish by salt. The second article, also a contribution from the same laboratory, is that of Donald K. Tressler who had been a temporary assistant in the Bureau. It deals at great length and in a detailed form with a method of salting fish applicable in warm climates. It shows wherein lie improvements that can be made with the existing methods that will work out better at a higher temperature. The article on the sardine industry is a report of the investigation done at Eastport on the canning of sardines on the coast of Maine, with suggestions for improving faulty methods, for the elimination of all unnecessary waste, and for the economical utilization of the necessary waste. The paper is the result of four years of study made by F. C. Weber, chemist in charge with the collaboration of others assigned to this work. None of the three papers reviewed has touched upon the peculiar situation of the lost weight being regained in time in the case of the brine and pickle cured fish. Mention is made of this fact in the last article on mild cured salmon. No experimental work is presented, however, to form a basis for comparative study.

## SUPPLIES

For these experiments, herring and codfish bought at downtown and wholesale markets were used. No great difficulty was encountered in obtaining good results when the coarse, half-ground California sea-salt was used, since it served

the purposes for the three cures employed. For testing the percentage of saturation of brine, an instrument called the salinometer was used. It is graduated to scale and is applicable to conditions at 60°F. In connection with its use, a graduate was found to be serviceable. For Experiment I, performed on gibbed herring, wooden containers were used. It was found out later that they proved unsatisfactory because of the brine and pickle being absorbed by the wood. It was necessary, therefore, to replace those used for brine and pickle curing with smooth stone jars. Wooden ones for the kench salting were retained as no effect could be found in the results. A tin pan was used when weighing fish, which was done on a six-pound Fairbanks balance.

## EXPERIMENTAL WORK

*Modes of Procedure.*

In the laboratory, the fish were given a thorough washing to remove the dirt and slime from their body, the scales left on. Then followed the gibbing of the herring, which was accomplished by making a triangular cut at the throat, the gills of the fish cut out, and the viscera with the exception of milt and roe pulled out. The fish were first graded according to size, and the fish of each size were equally distributed into three lots. Each of these lots was then weighed to exactly 62.50 ounces with the view to facilitate computations and make direct comparisons between the three cures. As the fish were yet wet, each lot was placed on the tray, giving the water a chance to drain until it practically stopped dripping. For this purpose, a standard time of five minutes was applied, which was followed throughout the experiment. A highly concentrated salt solution was prepared for the brine cure in a wooden kit by dissolving as much of the half-ground California sea-salt in one half-gallon of water until the brine tested 97% on the salinometer. Into this solution, the fish from one lot was placed without special manner of arrangement, and on the top layer of which have been added 3.5 ounces of salt, so as to maintain the strength of brine. Sufficient salt had been added so that the total amount of salt present in the cure was equivalent to one-third the weight of the fish. In the other two cures, the fish were given a preliminary rousing, which involved the rolling of fish in the salt. This salt had been weighed beforehand to the proportion of one ounce of salt to two ounces of fish. With a little salt sprinkled at the bottom of the kit and jar, the fish were laid down with the bellies up slightly on slant, and the different layers at right angles with each other as in the Norwegian cure, and the rest of salt left after the rousing process was spread on each layer. The fish were laid in the same manner after each observation and what was left of the salt was spread over each layer of fish as before. Several holes were purposely drilled at the bottom of the kit before the packing was made for the kench cure, the idea being to allow the pickle formed by the fish or, in other words, the moisture extracted by salt to run out. In the other cure the pickle thus formed was allowed to remain in the container. A sufficient amount of weight was placed on both the brine and pickled fish so as to keep them submerged under the liquor. All of these lots were kept in the same room where the temperature was fairly cool and had been nearly so throughout the period covered by this experiment; thus the fish were affected by practically the same conditions. Every two days or less observations were made regarding the loss or increase in the weight of the fish, and in each instance the amount or strength of the salt solution was brought up to its standard condition.

The methods stated above were followed in the first experiment on herring. After this experience, defects discovered made it necessary to make important changes in some of the methods worked

out in the rest of the experiments. Variation in the former results obtained was undoubtedly due partly to the scales being not removed from the body of the fish. Due to constant handling, especially when the examinations had to be made daily, the scales left on the fish were knocked off, thus causing somewhat of an unavoidable error in the weighing. The practice of removing scales was, therefore, applied in Experiments II and III as well as for Experiment IV. In the case of Experiments II and III, gibbing was eliminated. Some grains of salt and liquor which could not be easily removed were found sticking in the body cavity of the fish. The draining of the fish was done away with for the simple reason that such a method could apply well only to both the brine and pickle cured fish which could not be made as dry as the kench cured fish, no matter how long they were drained. It was considered an improvement over this practice the wiping of the pickle off the body of the fish with a piece of cloth. The lean cod used for Experiment IV being of larger size, was cut up in halves, head, entrails, fins, and bones removed. Each half was cut into pieces to make a nice pack in the wooden kits and stone jars.

The several methods performed in Experiment I were essentially the same as in the rest of the series. In all cases, great emphasis was placed on the uniformity of procedure throughout the experimental work.

### EXPERIMENT I

Table 1 gives the data on the effect of the brine, pickle, and kench cure on the fish. A graphical representation of the same is shown in Figure 1, which indicates the tendency of the fish to lose weight and in some instances to gain. On examination of the fish at the end of two days, there was noted a sudden large decrease in the weight. In the case of those

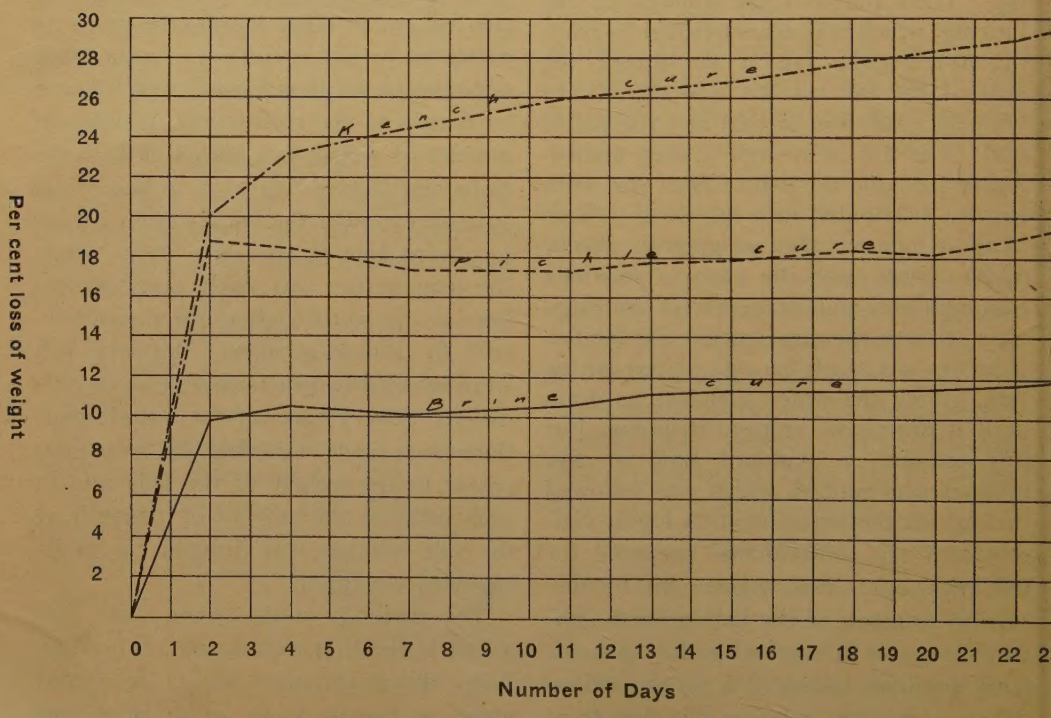


Fig. 1—Curves to show comparative loss of weight of brine cured, pickle cured, and kench cured gibbed herring.

kept in brine the amount of loss was 6.10 ounces or 9.76% of the original weight. Although some salt was added on top of the fish at start, it was found out that brine read 97% salinometer test after twenty-four hours. This immediate decrease was mainly due to the rapid movement outward of the water in the fish. To this diluted brine was added enough salt for the first two or three days or until it became saturated, or nearly so, for the rest of the time. It is interesting to note that at the end of the seventh day an increase in weight occurred as shown in Fig. I. After that time, the loss was steady throughout.

Fish held in the pickle cure weighed at the end of two days 50.80 ounces, or a loss of 18.12% from the former weight. This is nearly twice as much as the amount lost in the first method. This large decrease was further evidenced by the quantity of pickle formed which was enough to cover the fish. According to the salinometer, the pickle appeared to be saturated and was observed to remain so during the entire run of the experiment. This condition was due to the amount of salt, which was enough to keep up the strength of the solution. As in the case of the former method, the pickle cured fish increased in weight to an appreciable extent, but at two different times, that is, on the fourth and twentieth day.

Apparently, the water contained in the fish diffused out more rapidly and steadily in the kench method, the loss being 20% of the original weight at the end of two days and 29.28% after twenty-three days had elapsed. In no instance an increase over the preceding loss was registered.

TABLE I

Comparative Loss of Weight of Brine Cured, Pickle Cured and Kench Cured Gibbed Herring

| | BRINE CURE | | | PICKLE CURE | | | KENCH CURE | | |
|---|---|---|---|---|---|---|---|---|---|
| Number of Days | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss |
| 0 | 62.50 | 0.00 | 0.00 | 62.50 | 0.00 | 0.00 | 62.50 | 0.00 | 0.00 |
| 2 | 56.40 | 6.10 | 9.76 | 50.80 | 11.70 | 18.72 | 50.00 | 12.50 | 20.00 |
| 4 | 56.00 | 6.50 | 10.40 | 51.00 | 11.50 | 18.40 | 48.00 | 14.50 | 23.20 |
| 7 | 56.20 | 6.30 | 10.08 | 51.60 | 10.90 | 17.44 | 47.25 | 15.25 | 24.40 |
| 11 | 55.90 | 6.60 | 10.56 | 51.60 | 10.90 | 17.44 | 46.25 | 16.25 | 26.00 |
| 13 | 55.50 | 7.00 | 11.20 | 51.40 | 11.10 | 17.76 | 46.00 | 16.50 | 26.40 |
| 15 | 55.45 | 7.05 | 11.28 | 51.30 | 11.20 | 17.92 | 45.75 | 16.75 | 26.80 |
| 18 | 55.40 | 7.10 | 11.36 | 51.00 | 11.50 | 18.40 | 45.20 | 17.30 | 27.68 |
| 20 | 55.30 | 7.20 | 11.52 | 51.15 | 11.35 | 18.16 | 44.80 | 17.70 | 28.32 |
| 22 | 55.20 | 7.30 | 11.68 | 50.65 | 11.85 | 18.96 | 44.50 | 18.00 | 28.80 |
| 23 | 55.10 | 7.40 | 11.84 | 50.50 | 12.10 | 19.36 | 44.20 | 18.30 | 29.28 |

**EXPERIMENTS II and III**

Experiment I was followed by two others performed with fish of the same species and of the same relative freshness. They were undertaken at the same time, during the early part of the spring quarter in order, if possible, to determine what affected the changes taking place in the curing of fish, since one experiment could check the other. In working out these experiments, some new things have been introduced in the methods of cleaning the fish and in the removing of moisture from their body. The fish were thoroughly scaled, and the fish were salted round, the practice of gibbing being abandoned. Water from the body of the fish was removed by wiping it off with a moist cloth. It was considered that with such improvements added, the results obtained were somewhat more accurate. These results are given in Tables 2 and 3, and are shown graphically in the curves, Figures 2 and 3.

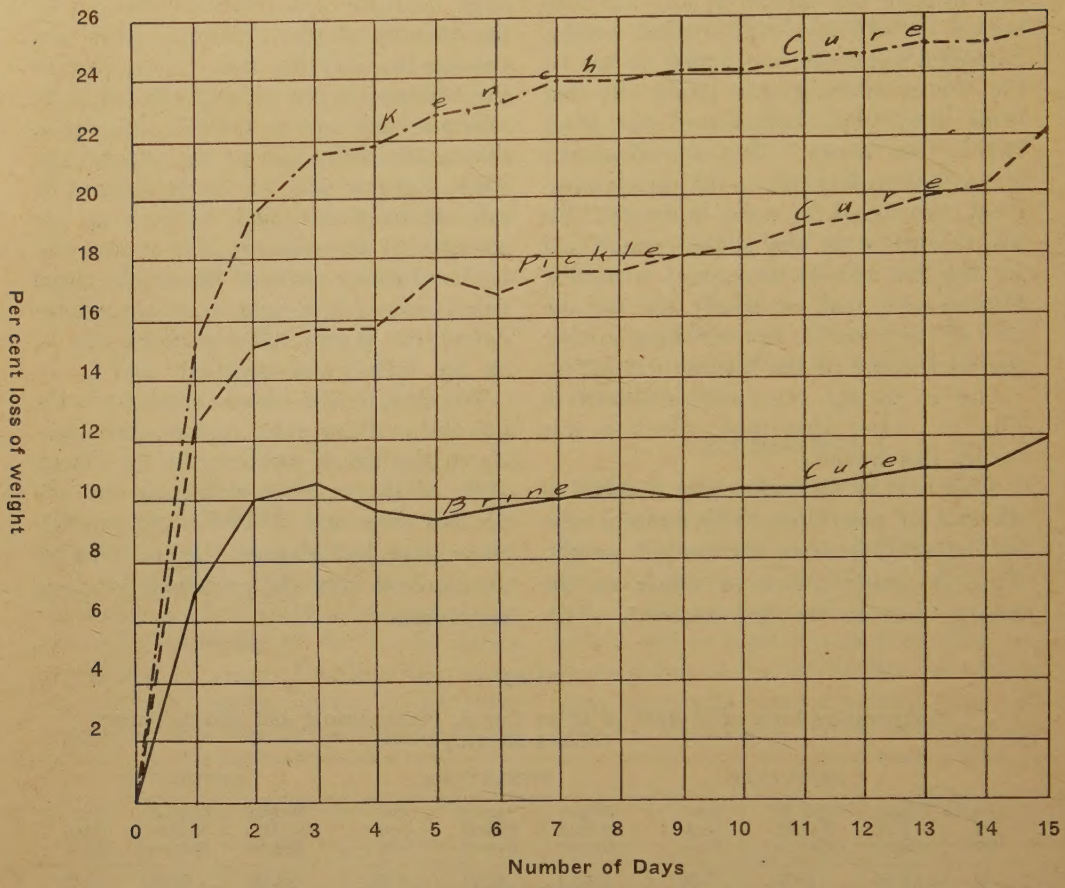


Fig. 2—Curves to show comparative loss of weight of brine cured, pickle cured, and kench cured round herring. (Experiment II.)

A comparison of the tables and figures shows that there was a great similarity in the results obtained. The brine cure in both cases started with a small loss of weight after 24 hours curing, steadily losing more until the fourth day, when the fish gained a few ounces. The fifth day was marked by further gain, then followed by a continued decrease till the ninth day when for the last time a quarter of an ounce was gained. As the graphs represent the tendency of fish to lose weight, these gains will appear as depressions in the curves. The total loss in weight is 11.89% of the original weight of herring used for Experiment II, corresponding to 12.50% in Experiment III. At the beginning, the brine employed was tested 96% salinometer and became only 73% the next day. With the addition of a little salt for the first two or three days, the brine solution remained saturated for the rest of the run.

The pickle cure on the other hand extracted nearly twice as much moisture from the fish as the brine method, and there was a difference of only a quarter of an ounce at the end of the first day between the two experiments. The fish did not gain weight until after the sixth day, a condition which held true in both cases. In the first experiment, this change occurred but once, but in the other it was registered again after eight days, as shown in Figure 3. As was shown in Experiment I, the pickle formed did not

become weakened, since there was enough salt left which could counteract the action of the water coming from the fish.

The kench cured fish suffered a slightly greater loss of weight than those salted by the pickle method, at the end of every observation made. After the first day, the drop was 11.75 ounces or 15.10% of the original weight, being greater than any other weight registered for the same length of time. Another important feature of the kench cured fish was that they never gained weight under the ordinary conditions.

Data indicate that either they lost weight or remained the same, but never increased. Figure 3 shows the curve of the kench cure to be a steady rise.

EXPERIMENT IV

The changes which the codfish packed in brine, pickle and kench cures underwent at certain intervals of time are shown in Table 4. As the investigation was intended to cover as many kinds of fish as were available, lean cod was used. The experiment was, therefore, performed on a fish of entirely different species and form, but the modes of procedure resorted to were the same as in the previous experiments. As the fish were split, there was some of the flesh exposed and some changes from the other experiments were to be expected in the readings.

The curve for the brine cure shows that the fish increased in weight at three

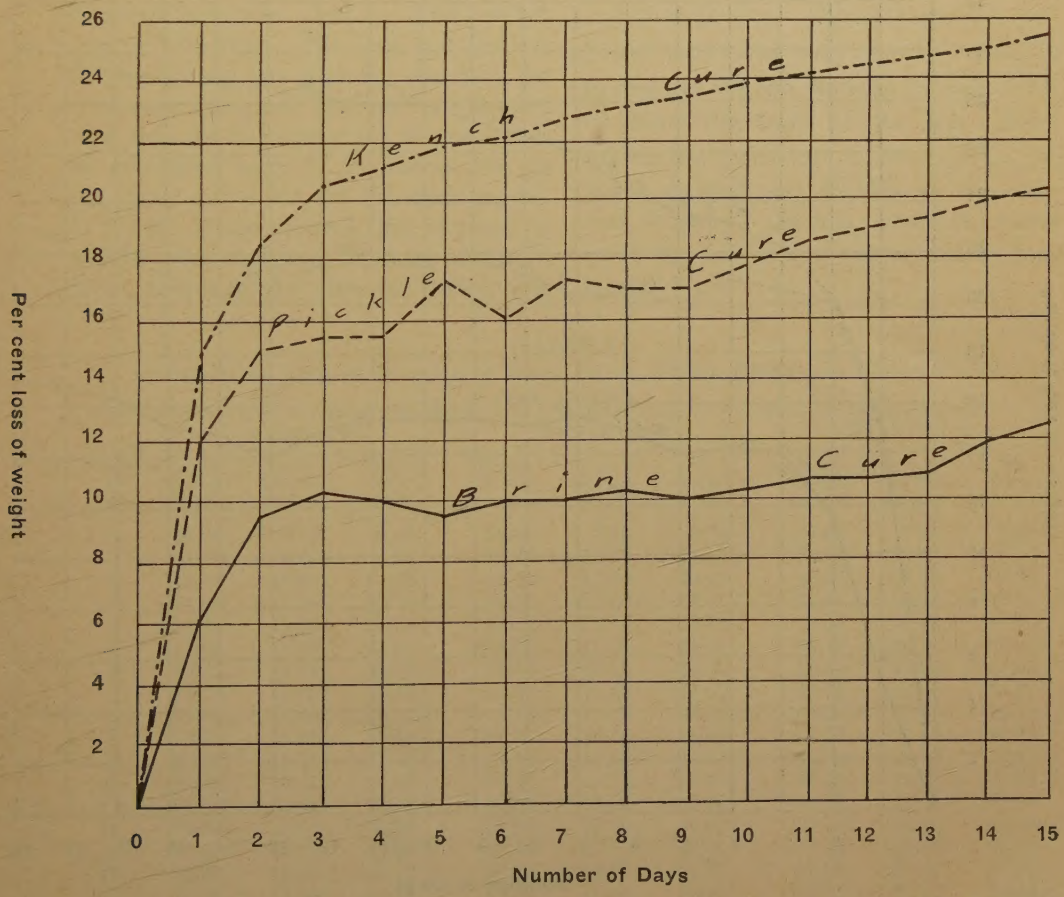


Fig. 3—Curves to show comparative loss of weight of brine cured, pickled cured, kench cured round herring. (Experiment III.)

TABLE 2

Comparative Loss of Weight of Brine Cured, Pickle Cured and Kench Cured Round Herring

| | BRINE CURE | | | PICKLE CURE | | | KENCH CURE | | |
|---|---|---|---|---|---|---|---|---|---|
| Number of Days | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss |
| 0 | 77.75 | 0.00 | 0.00 | 77.75 | 0.00 | 0.00 | 77.75 | 0.00 | 0.00 |
| 1 | 72.25 | 5.50 | 7.07 | 68.00 | 9.75 | 12.50 | 66.00 | 11.75 | 15.10 |
| 2 | 70.00 | 7.75 | 9.97 | 66.00 | 11.75 | 15.10 | 62.75 | 15.00 | 19.30 |
| 3 | 69.50 | 8.25 | 10.60 | 65.50 | 12.25 | 15.76 | 61.00 | 16.75 | 21.54 |
| 4 | 70.25 | 7.50 | 9.65 | 65.50 | 12.25 | 15.76 | 60.75 | 17.00 | 21.87 |
| 5 | 70.50 | 7.25 | 9.32 | 64.25 | 13.50 | 17.36 | 60.00 | 17.75 | 22.83 |
| 6 | 70.25 | 7.50 | 9.65 | 64.75 | 13.00 | 16.72 | 59.75 | 18.00 | 23.15 |
| 7 | 70.00 | 7.75 | 9.97 | 64.25 | 13.50 | 17.36 | 59.25 | 18.50 | 23.78 |
| 8 | 69.75 | 8.00 | 10.30 | 64.25 | 13.50 | 17.36 | 59.25 | 18.50 | 23.78 |
| 9 | 70.00 | 7.75 | 9.97 | 63.75 | 14.00 | 18.00 | 59.00 | 18.75 | 24.12 |
| 10 | 69.75 | 8.00 | 10.30 | 63.50 | 14.25 | 18.33 | 59.00 | 18.75 | 24.12 |
| 11 | 69.75 | 8.00 | 10.30 | 63.00 | 14.75 | 18.97 | 58.75 | 19.00 | 24.44 |
| 12 | 69.50 | 8.25 | 10.60 | 62.75 | 15.00 | 19.30 | 58.50 | 19.25 | 24.76 |
| 13 | 69.25 | 8.50 | 10.93 | 62.25 | 15.50 | 19.93 | 58.25 | 19.50 | 25.00 |
| 14 | 69.25 | 8.50 | 10.93 | 62.00 | 15.75 | 20.26 | 58.25 | 19.50 | 25.00 |
| 15 | 68.00 | 9.25 | 11.89 | 60.50 | 17.25 | 22.19 | 58.00 | 19.75 | 25.40 |

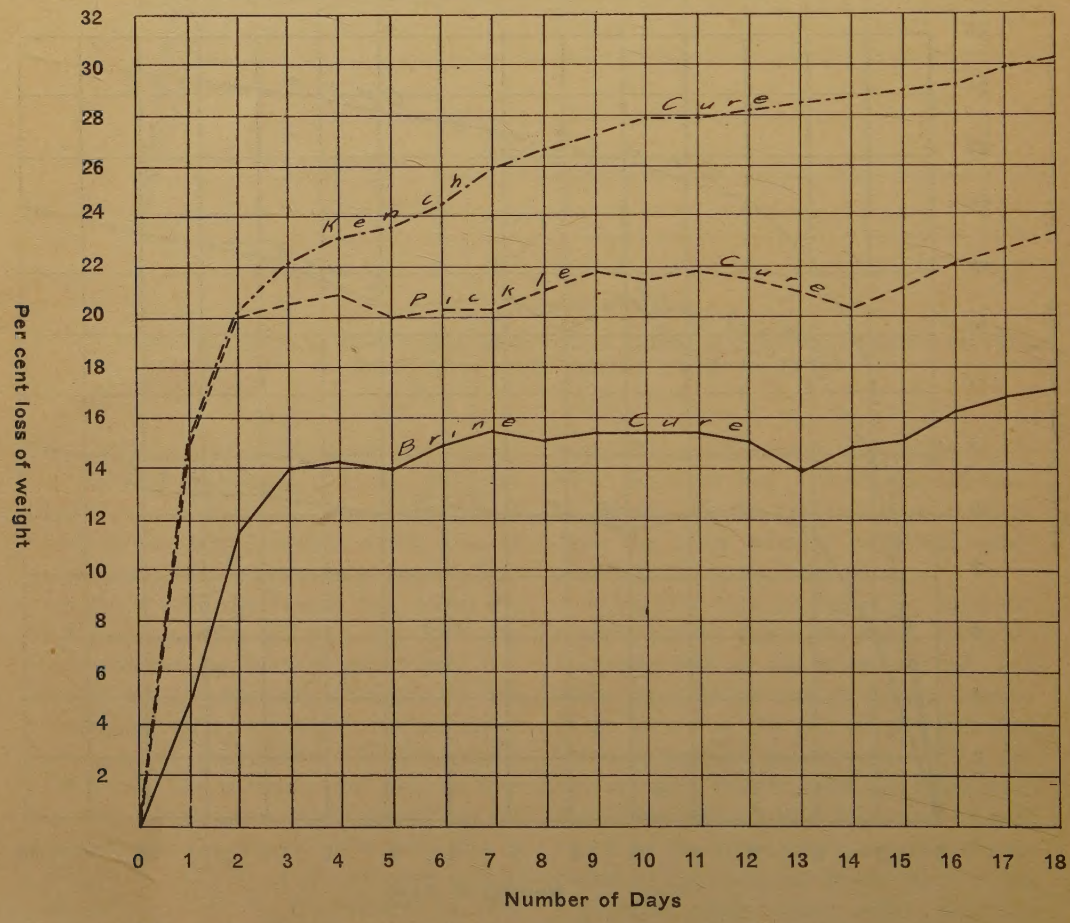


Fig. 4—Showing curves of the comparative loss of weight of brine cured, pickle cured and kench cured split codfish.

TABLE 3

Comparative Loss of Weight of Brine Cured, Pickle Cured and Kench Cured Round Herring (Experiment III)

| | BRINE CURE | | | PICKLE CURE | | | KENCH CURE | | |
|---|---|---|---|---|---|---|---|---|---|
| Number of Days | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss |
| 0 | 77.75 | 0.00 | 0.00 | 77.75 | 0.00 | 0.00 | 77.75 | 0.00 | 0.00 |
| 1 | 73.00 | 4.75 | 6.10 | 67.75 | 10.00 | 12.00 | 66.25 | 11.50 | 14.80 |
| 2 | 70.25 | 7.50 | 9.65 | 66.00 | 11.75 | 15.10 | 63.25 | 14.50 | 18.65 |
| 3 | 69.75 | 8.00 | 10.30 | 65.75 | 12.00 | 15.43 | 61.75 | 16.00 | 20.60 |
| 4 | 70.00 | 7.75 | 9.97 | 65.75 | 12.00 | 15.43 | 61.25 | 16.50 | 21.20 |
| 5 | 70.25 | 7.50 | 9.65 | 64.25 | 13.50 | 17.36 | 60.75 | 17.00 | 21.87 |
| 6 | 70.00 | 7.75 | 9.97 | 65.25 | 12.50 | 16.07 | 60.50 | 17.25 | 22.19 |
| 7 | 70.00 | 7.75 | 9.97 | 64.25 | 13.50 | 17.36 | 60.00 | 17.75 | 22.83 |
| 8 | 69.75 | 8.00 | 10.30 | 64.50 | 13.25 | 17.04 | 59.75 | 18.00 | 23.15 |
| 9 | 70.00 | 7.75 | 9.97 | 64.50 | 13.25 | 17.04 | 59.50 | 18.25 | 23.45 |
| 10 | 69.75 | 8.00 | 10.30 | 64.00 | 13.75 | 17.70 | 59.25 | 18.50 | 23.78 |
| 11 | 69.50 | 8.25 | 10.60 | 63.25 | 14.50 | 18.65 | 59.00 | 18.75 | 24.12 |
| 12 | 69.50 | 8.25 | 10.60 | 63.00 | 14.75 | 18.97 | 58.75 | 19.00 | 24.44 |
| 13 | 69.25 | 8.50 | 10.93 | 62.75 | 15.00 | 19.30 | 58.50 | 19.25 | 24.76 |
| 14 | 68.50 | 9.25 | 11.89 | 62.25 | 15.50 | 19.93 | 58.25 | 19.50 | 25.00 |
| 15 | 68.00 | 9.75 | 12.50 | 62.00 | 15.75 | 20.26 | 58.00 | 19.75 | 25.40 |

different instances, after the fifth, eighth and twelfth day. The loss was greater for the second day than for the first, the difference being one and one half ounces, or a total of 10 ounces for the two days as compared with 17.25 ounces loss in the pickle cured fish for the same period. With the latter method, the increase in weight also occurred at three different times, that is to say, after the fifth, tenth, and twelfth day. There were also sufficient water and body juices of the fish to dissolve the salt, making enough pickle to cover the body of the fish. After fifteen days, the loss in the case of the kench method was 30.24% of the original weight of the fish, which is exactly twice the loss at the end of twenty-four hours.

TABLE 4

Comparative Loss of Weights of Brine Cured, Pickle Cured and Kench Cured Split Codfish

| | BRINE CURE | | | PICKLE CURE | | | KENCH CURE | | |
|---|---|---|---|---|---|---|---|---|---|
| Number of Days | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss | Weight of Fish Ounces | Loss of Weight Ounces | Per Cent Loss |
| 0 | 86.00 | 0.00 | 0.00 | 86.00 | 0.00 | 0.00 | 86.00 | 0.00 | 0.00 |
| 1 | 81.75 | 4.25 | 4.94 | 73.25 | 12.75 | 14.83 | 73.00 | 13.00 | 15.12 |
| 2 | 76.00 | 10.00 | 11.63 | 68.75 | 17.25 | 20.00 | 68.50 | 17.50 | 20.35 |
| 3 | 74.00 | 12.00 | 13.95 | 68.25 | 17.75 | 20.64 | 67.00 | 19.00 | 22.10 |
| 4 | 73.75 | 12.25 | 14.24 | 68.00 | 18.00 | 20.93 | 66.00 | 20.00 | 23.26 |
| 5 | 74.00 | 12.00 | 13.95 | 68.75 | 17.25 | 20.00 | 65.75 | 20.25 | 23.54 |
| 6 | 73.25 | 12.75 | 14.83 | 68.50 | 17.50 | 20.35 | 65.00 | 21.00 | 24.40 |
| 7 | 72.75 | 13.25 | 15.40 | 68.50 | 17.50 | 20.35 | 63.75 | 22.25 | 25.87 |
| 8 | 73.00 | 13.00 | 15.12 | 67.75 | 18.25 | 21.22 | 63.00 | 23.00 | 26.74 |
| 9 | 72.75 | 13.25 | 15.40 | 67.25 | 18.75 | 21.80 | 62.50 | 23.50 | 27.33 |
| 10 | 72.75 | 13.25 | 15.40 | 67.50 | 18.50 | 21.50 | 62.00 | 24.00 | 27.90 |
| 11 | 72.75 | 13.25 | 15.40 | 67.25 | 18.75 | 21.80 | 62.00 | 24.00 | 27.90 |
| 12 | 73.00 | 13.00 | 15.12 | 67.50 | 18.50 | 21.50 | 61.75 | 24.25 | 28.20 |
| 13 | 74.00 | 12.00 | 13.95 | 68.00 | 18.00 | 20.93 | 61.50 | 24.50 | 28.50 |
| 14 | 73.25 | 12.75 | 14.83 | 68.50 | 17.50 | 20.35 | 61.25 | 24.75 | 28.78 |
| 15 | 73.00 | 13.00 | 15.12 | 67.75 | 18.25 | 21.22 | 61.00 | 25.00 | 29.07 |
| 16 | 72.00 | 14.00 | 16.28 | 67.00 | 19.00 | 22.10 | 60.75 | 25.25 | 29.36 |
| 17 | 71.50 | 14.50 | 16.86 | 66.50 | 19.50 | 22.67 | 60.25 | 25.75 | 29.95 |
| 18 | 71.25 | 14.75 | 17.15 | 66.00 | 20.00 | 23.26 | 60.00 | 26.00 | 30.24 |

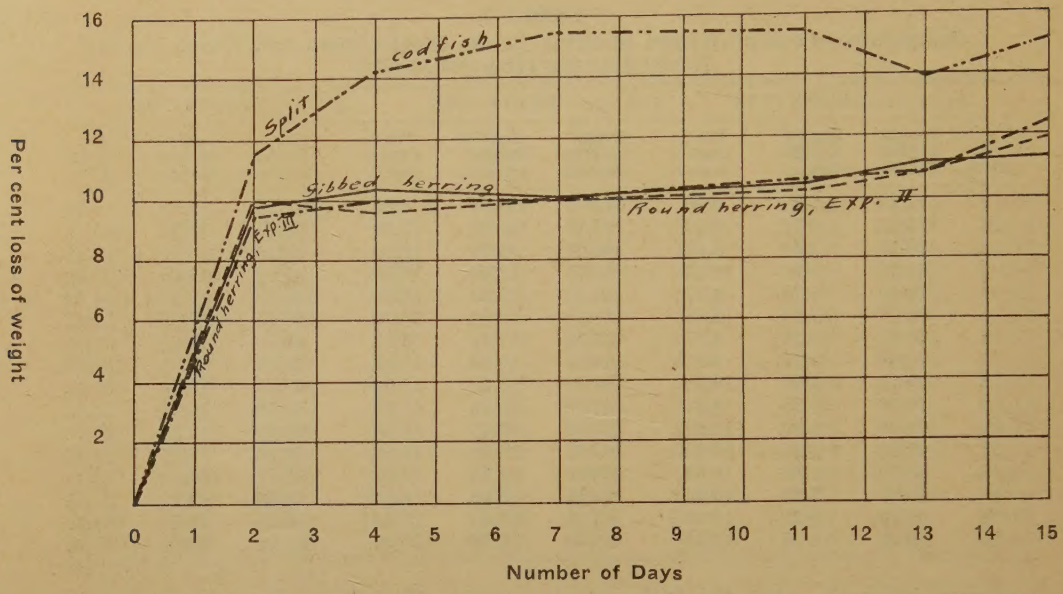


Fig. 5—Curves to show comparative loss of weight of different kinds of fish by brine salting.

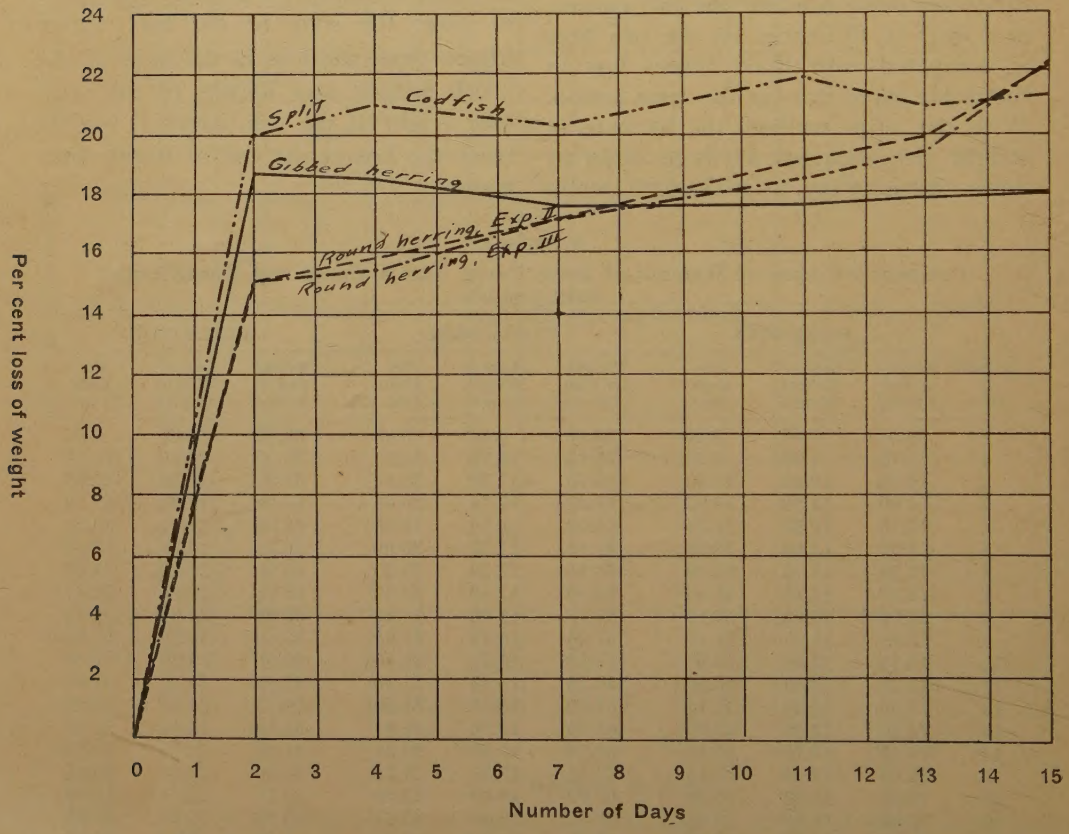


Fig. 6—Comparative loss of weight of different kinds of fish by pickle curing.

### SUPPLEMENTARY DATA

Based upon the preceding results of analysis are Tables 5 and 6. In the first the percentage data on each lot of fish are presented under each kind of cure. Figures 5, 6, and 7 illustrate graphically the data. By referring to both the tables and curves, a direct comparison can be easily made regarding the relative efficiency of the three methods in removing moisture from the different kinds of fish. A more general idea of this efficiency can be expressed by taking the average of the per cent loss from each experiment under each cure, as given in Table 6 and presented graphically by Figure 8.

It appears that where fish were surrounded with salt solution there was a tendency towards alternate decreasing and increasing variation in the weight of fish. Just what influenced this condition was not fully determined. It is now well understood that the action of salt is to penetrate the fish and to remove the water. The process of transferring water from one place to another, as from the inside of the fish to the outside, through a membrane under the influence of a concentrated solution is called osmosis, and the tendency of flow is towards a medium of lesser density. The dividing membrane in this case is the skin of the

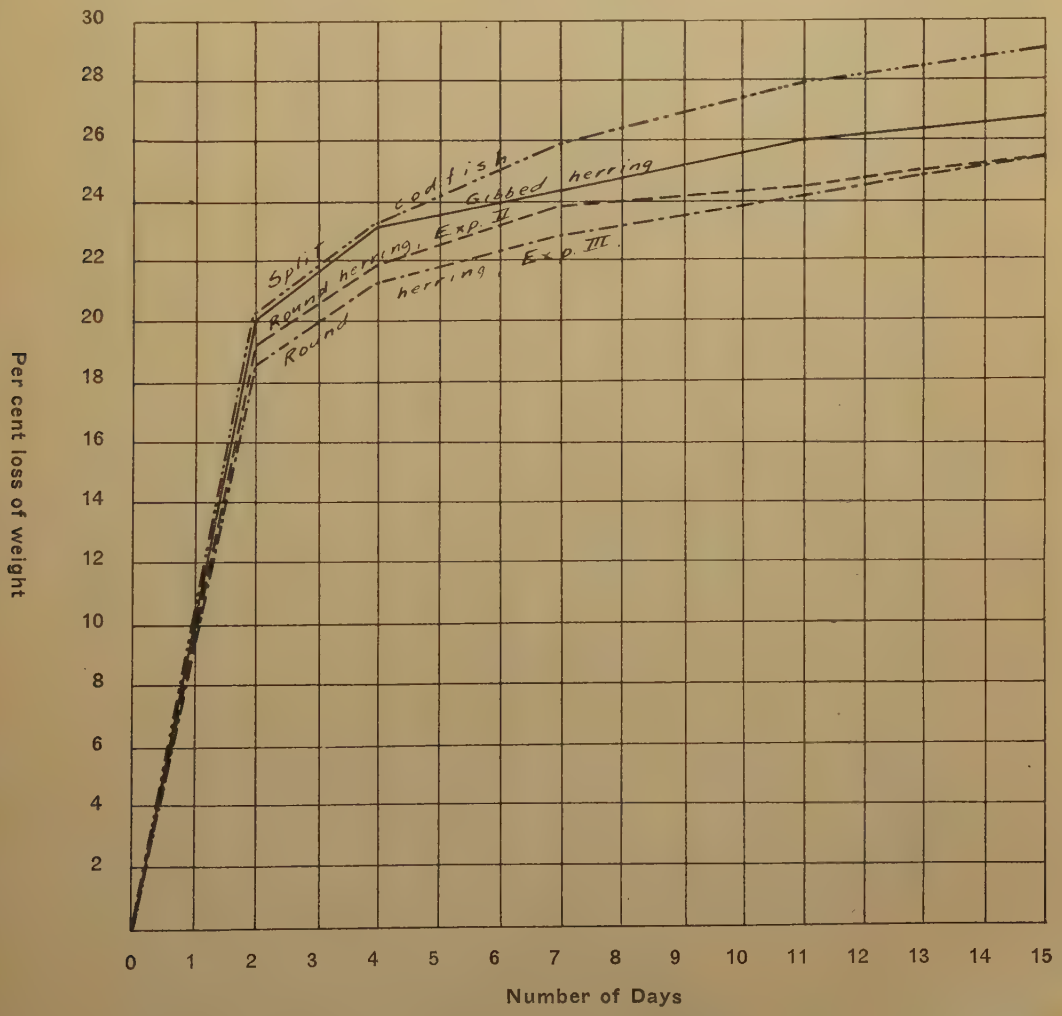


Fig. 7—Comparative loss of weight of different kinds of fish by kench method.

fish and the cell walls. When dry salt and salt solution were brought in contact with fish, water passed out of the body letting salt take its place. After a time we would expect the two solutions, one in the fish and the other outside, to become of the same strength, when the flow of water would stop. But what influenced the alternate variation in the weight of the brine and pickle cured fish? It is hoped that future experiments will throw more light on this particular phenomenon. The curves show that in the split codfish the penetration of salt was more rapid than in the unskinned herring.

Figure 6 represents that the percentage of loss was higher throughout in the case of the kench cured fish than in the other kinds. This is an indication of the more rapid penetration of salt. In the three methods, however, the loss was greatest during the first two or three days.

*New Changes Noted on Fish.*

The fish produced by the brine and pickle methods were soft and contained much water. They acquired a peculiar odor and bleached appearance. Considerable numbers, especially those kench cured, had their bellies breaking away. However, most of the fish were plumper and seemed to be more like fresh fish

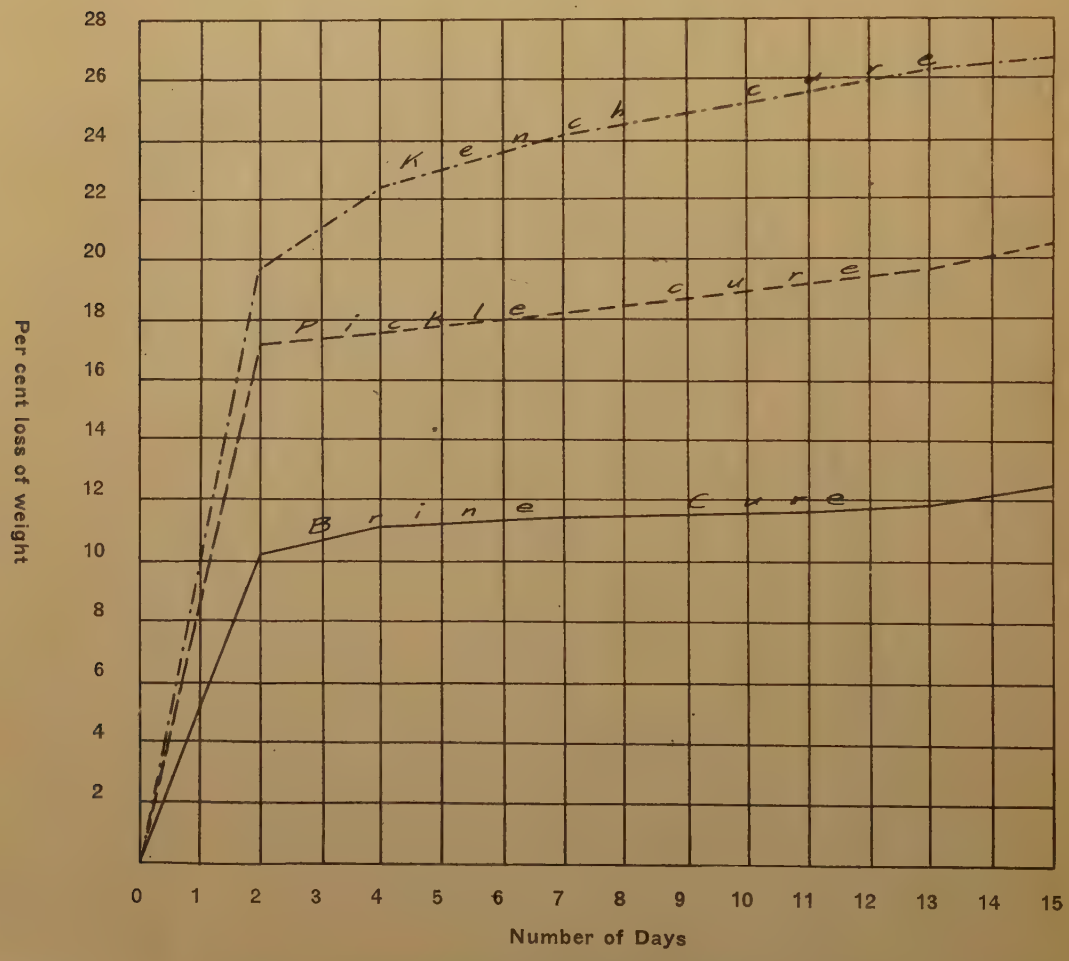


Fig. 8—Curves to show the average efficiency of brine, pickle and kench methods of curing fish.

TABLE 5

Comparative Loss of Weight of Different Kinds of Fish Under Each Method of Cure

| | BRINE CURE | | | | PICKLED CURE | | | | KENCH CURE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of Days | Gibbed Herring | Round Herring | Round Herring | Split Codfish | Gibbed Herring | Round Herring | Round Herring | Split Codfish | Gibbed Herring | Round Herring | Round Herring | Split Codfish |
| | Exp. II | Exp. III | | | Exp. II | Exp. III | | | Exp. II | Exp. III | | |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | ..... | 7.07 | 6.10 | 4.94 | ..... | 12.50 | 12.00 | 14.83 | ..... | 15.10 | 14.80 | 15.12 |
| 2 | 9.76 | 9.97 | 9.65 | 11.63 | 18.72 | 15.10 | 15.10 | 20.00 | 20.00 | 19.30 | 18.65 | 20.35 |
| 3 | ..... | 10.60 | 10.30 | 13.95 | ..... | 15.76 | 15.43 | 20.64 | ..... | 21.54 | 20.60 | 22.10 |
| 4 | 10.40 | 9.65 | 9.97 | 14.24 | 18.40 | 15.76 | 15.43 | 20.93 | 23.20 | 21.87 | 21.20 | 23.26 |
| 5 | ..... | 9.32 | 9.65 | 13.95 | ..... | 17.36 | 17.36 | 20.00 | ..... | 22.83 | 21.87 | 23.54 |
| 6 | ..... | 9.65 | 9.97 | 14.83 | ..... | 16.72 | 16.07 | 20.35 | ..... | 23.15 | 22.19 | 24.40 |
| 7 | 10.08 | 9.97 | 9.97 | 15.40 | 17.44 | 17.36 | 17.36 | 20.35 | 24.40 | 23.78 | 22.83 | 25.87 |
| 8 | ..... | 10.30 | 10.30 | 15.12 | ..... | 17.36 | 17.04 | 21.22 | ..... | 23.78 | 23.15 | 26.74 |
| 9 | ..... | 9.97 | 9.97 | 15.40 | ..... | 18.00 | 17.04 | 21.80 | ..... | 24.12 | 23.45 | 27.33 |
| 10 | ..... | 10.30 | 10.30 | 15.40 | ..... | 18.33 | 17.70 | 21.50 | ..... | 24.12 | 23.78 | 27.90 |
| 11 | 10.56 | 10.30 | 10.60 | 15.40 | 17.44 | 18.97 | 18.65 | 21.80 | 26.00 | 24.44 | 24.12 | 27.90 |
| 12 | ..... | 10.60 | 10.60 | 15.12 | ..... | 19.30 | 18.97 | 21.50 | ..... | 24.76 | 24.44 | 28.20 |
| 13 | 11.20 | 10.93 | 10.93 | 13.95 | 17.76 | 19.93 | 19.30 | 20.93 | 26.40 | 25.00 | 24.76 | 28.50 |
| 14 | ..... | 10.93 | 11.89 | 14.83 | ..... | 20.26 | 19.93 | 20.35 | ..... | 25.00 | 25.00 | 28.78 |
| 15 | 11.28 | 11.89 | 12.50 | 15.12 | 17.92 | 22.19 | 20.26 | 21.22 | 26.80 | 25.40 | 25.40 | 29.07 |
| 16 | ..... | ..... | ..... | 16.28 | ..... | ..... | ..... | 22.10 | ..... | ..... | ..... | 29.36 |
| 17 | ..... | ..... | ..... | 16.86 | ..... | ..... | ..... | 22.67 | ..... | ..... | ..... | 29.95 |
| 18 | 11.36 | ..... | ..... | 17.15 | 18.40 | ..... | ..... | 23.26 | 27.68 | ..... | ..... | 30.24 |
| 19 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 20 | 11.52 | ..... | ..... | ..... | 18.16 | ..... | ..... | ..... | 28.32 | ..... | ..... | ..... |
| 21 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 22 | 11.68 | ..... | ..... | ..... | 18.96 | ..... | ..... | ..... | 28.80 | ..... | ..... | ..... |
| 23 | 11.84 | ..... | ..... | ..... | 19.36 | ..... | ..... | ..... | 29.28 | ..... | ..... | ..... |

than the dry salted product. It appeared that with the kench curing there was less of shrinkage and shriveling of the fish, the natural bright color of the skin being nearly retained. Fish exposed to the air was very likely to "rust," and this condition was particularly noticeable with the kench cured herring and cod. Rusting was due to the oxidation of the oil present in the fish, giving them a dark brown color. In connecton with this cure it is also important to note that the extraction of water from the fish cannot be ascribed to the action of salt alone, but also to evaporation. Packing in brine and pickle prevent both this action and that of oxidation. Although there was a gradual formation of brine in the first two methods, there was also a simultaneous decrease in its volume due to some part of it escaping through evaporation.

*Probable Sources of Error.*

It is to be expected that unavoidable mistakes were made, no matter how much care was taken in carrying out this work. After an experience with the first experiment it was found that the draining of water from the fish was defective, because it could not apply well to the kench cure. Another system devised consisted of wiping off the moisture from the body, but even if this was considered an improvement over the other it had its own flaw, because the amount of moisture removed in this way could not be determined. Variation in results can be traced also to the process of gibbing, leaving a secure place for moisture and salt to settle, thus escaping notice, sometimes. Although the methods may be defective, they have been so improved and standardized that the errors have been reduced to

TABLE 6

Average Efficiency of Brine, Pickle and Kench Methods of Curing Fish

| No. of Days | Brine Cure | Pickle Cure | Kench Cure |
|---|---|---|---|
| 1 | ..... | ..... | ..... |
| 2 | 10.25 | 17.23 | 19.57 |
| 3 | ..... | ..... | ..... |
| 4 | 11.07 | 17.63 | 22.38 |
| 5 | ..... | ..... | ..... |
| 6 | ..... | ..... | ..... |
| 7 | 11.35 | 18.13 | 24.22 |
| 8 | ..... | ..... | ..... |
| 9 | ..... | ..... | ..... |
| 10 | ..... | ..... | ..... |
| 11 | 11.72 | 19.22 | 25.62 |
| 12 | ..... | ..... | ..... |
| 13 | 11.75 | 19.48 | 26.17 |
| 14 | ..... | ..... | ..... |
| 15 | 12.56 | 20.40 | 26.67 |

a minimum. Under ordinary circumstances we find that there were errors due to other sources as given in the following:

1. Difference in the accuracy of observation.

2. The fish were not of the same size and shape, hence there was unequal amount of surface exposed and there would be a difference in the amount of salt absorbed.

3. The fish may not be of the same thickness, and naturally it took longer time for the salt to go through the body of a thicker fish.

4. The amount of fat in the different fish may also vary somewhat. When the fish were examined some of them had melt and roe and others immature or spawned out. The fat that may be present might alter the permeability of the fish to salt.

5. Weather conditions also affected the results somewhat. It appeared that when the humidity was low, the decrease in the weight of the fish was greater. This condition manifested itself distinctly in the case of the kench cure.

6. Where the number of fish was not the same, the results were apt to vary. Greater number means more skin or flesh surface exposed.

## SUMMARY

1. As soon as the fish were placed in dry salt or salt solution the formation of pickle began, showing that appreciable quantity of water passed out of the fish. The principle upon which this action of salt in removing moisture from the fish acts is called osmosis.

2. Salt applied dry in the kench cure penetrates the fish more rapidly and extracts greater amount of water.

3. In the case of this kench method, the decrease in the weight of the fish is steady throughout.

4. This loss of weight is attributed not only to the action of salt, but also to the evaporation of moisture itself.

5. Where the fish are surrounded by both moisture and salt, the decrease and increase of weight may take place.

6. The brine solution becomes weakened right after the fish are plcaed in it, due to the mixture of water coming from the fish. Such a condition is not present in the pickle cure.

7. Salt penetrated split cod at a greater speed than the unskinned herring, which proves the great value of splitting fish preparatory to salting.

8. The results of the experiments show that fish cured by the three methods lose weight rapidly and heavily during the first two or three days.

# The Ayu, *Plecoglossus altivelis*, of Japan

By D. R. CRAWFORD
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University of Washington, Seattle

The ayu, or kogio, is a fish very much prized by the Japanese. It is much like our eulachon, or Columbia River smelt, but differs from it in several important characters. In life, the ayu is a pale bluish color above with an indistinct orange spot above the pectoral fin, the sides and belly being pale but not silvery. There is a certain translucence about the fish which is pearl-like and renders it inconspicuous even in clear water. During the spawning season the color changes to a dusky red, and the Japanese then call them *sabi*, or rusty.

Ayu run from the sea into the rivers to spawn during October, and, like our smelts, deposit their eggs on the bottom where they stick very tenaciously. The eggs are colorless and measure about 1/25 of an inch in diameter. The fry hatch in about three weeks and apparently remain in the stream until they are about an inch long, which may be the length reached in one or two years. They return to the sea and probably make the first spawning run at the age of two or three years. Many of them die after spawning from exhaustion and thus this ayu has received the name *Nengio*, or annual fish, and *Kuniswiwo*, or fish of omen. Many, however, return to the sea and spawn in following years. It is found in the rivers of southern Hokkaido and Hondo in Japan and also in Formosa.

There are interesting historical references to the ayu in Japanese literature. Mention of it is made as far back as 200 B.C. when the Empress Jingo made an expedition to Korea from China. While enroute, at Hizen, it appears that the imperial party engaged in sport fishing and took some of these fish by hook and line. So impressed was the Empress that she named the fish Ayu in remembrance of her Ayu, or "Eastern expedition." The ayu continued in imperial favor to the extent that it was protected and cultivated for the royal table in the old capital of Kyoto during the reign of the Emperor Saga.

References to catching the ayu for sport are numerous. Probably the oldest method and the one which today is the most unique is fishing with a cormorant. This method was introduced during the reign of the Emperor Jimmu over 2000 years ago, and is now best known in Mino province along the Nagaragawa. The well-known fish-catching ability of the cormorant is taken advantage of. The birds are trained to some extent and held in leash until fishing starts. A ring, or at least a piece of rope is put about the bird's neck so that when it catches a fish it cannot swallow it. The owner of the bird captures it again and makes it disgorge the fish.

Other methods of fishing for ayu vary according to the nature of the grounds. Cast nets are used in rivers where the water is shallow and the bottom rough, while drag nets are preferred in deeper water where the current is slow and the bottom is sandy or gravelly. Gill nets also are used.

The *machi-ami* is a sort of net, one end of which is staked to the ground and the other end held across the stream. This net catches the fish as they come down stream, presumably after spawning. The *hane-ami* is a device for scaring fish into the net with a scare line.

*Yana* is a weir set across a rapid stream. The weir is a screen made of reeds and it is set so that it slants down stream. The fish drifting down stream are caught and held against the reeds by the current where the fishermen, who are watching,

pick them off and put them into baskets.

Sport fishing with hook and line is a very old method of catching ayu, although lately artificial flies for this purpose are becoming popular. The fish is said to be gamey. Another method, called *tomozuri,* also is quite popular. A live fish is hooked through the mouth and allowed to swim about freely in the water. It acts as a lure to attract other fish which come within reach of the fishermen who then catch them.

The annual catch of ayu amounts to over 50,000 Yen (about $25,000) the largest part being taken in the province of Mino. Small lots of frozen ayu have been sent to the United States where they were sold during times when smelts were not available.

Several attempts have been made by the Japanese to introduce the ayu into the United States. The California Fish and Game Commission received shipments of eggs from time to time, but apparently the eggs died in transit. In 1922, the College of Fisheries received a shipment of ayu eggs, most of which were alive, and these eggs were hatched out. However, the larvae soon died. Two other shipments of eggs were made at various times, but the eggs were all dead upon arrival. The most elaborate attempt was in 1928, when a large number of live ayu were sent. In spite of every precaution being taken, only a few hundred fish reached Seattle alive, and of these many died before they could be taken from the dock. Several hundred were planted in Lake Washington, and a few were placed in the aquarium at the College of Fisheries where they lived a considerable time.

The ayu were very active and fed greedily on young salmon which would clearly indicate that they are not herbivorous as some Japanese believe. It is interesting also to note that the mouth is much larger in proportion to the head than the mouth of our Columbia River smelt, which shows that the usual food of the ayu could be something much larger than plankton.

It is very doubtful whether or not ayu will be successful in this country. The temperature range required for spawning rarely is reached in streams in the Northwest. There are many fishes in these waters now of equal or greater value than the ayu which would be either a menace to these fish or at least compete with these species for the food supply.

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# Dr. Kishinoue Dies In China

One of the most valued friends and coworkers with the Pan-Pacific Research Institution was Dr. Kenkichi Kishinoue of Japan. It is with deep regret that the Institution learns of his recent death in China while conducting fish research work on the Yangtse River as part of the work of the Sino-Japanese Cultural Institute.

Dr. Kishinoue was staying at Chengtu, Szechuan Province, for some time with his Chinese assistants, and had collected about 84 species of fish of the Yangtse.

Born in Aichi Prefecture, Dr. Kishinoue graduated from the Scientific Department of Tokyo Imperial University, having made a special study of biology, and obtained the degree of Doctor of Science six years after his graduation from the university. In 1891, he was appointed an official of the Agriculture and Commerce Office and made a study of the marine products and abroad. Since many years ago he held the office of honorary professor of Kyoto Imperial University, and was recognized by the scientific world as an authority on the study of tunney and bonito fish. In 1924 he was awarded the sum of Y8,900 by the Keimeikai for his scientific researches. He is survived by Mrs. Choko Kishinoue, four sons and three daughters.